Universitat Autònoma de Barcelona

2019/2020

Mechanics and Relativity

Code: 100137
ECTS Credits: 6

Degree	Type	Year	Semester
2500097 Physics	FB	1	1

Contact

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Use of Languages

Principal working language: catalan (cat)

Some groups entirely in English: No

Some groups entirely in Catalan: Yes

Some groups entirely in Spanish: No

Teachers

Emili Bagán Capella

Christian Neissner

Inés Temiño Gutierrez

John Calsamiglia Costa

José Flix Molina

Prerequisites

The course has two parts (about 7 weeks each) clearly differentiated. There are no prerequisites, but for each part the following recommendations are important:

For the mechanics section.

Mathematics: have a good knowledge of elementary algebra, including vector algebra; have elementary knowledge of calculus, in particular, of derivation, and notions of integration.

Physics: have basic knowledge of mechanics. Specifically: kinematics, forces, and Newtonian elementary dynamics.

Others: have good study habits that allow taking the subject up to date.

For the sections of Fluids and Relativity.

Mathematics: Have a good knowledge of basic mathematics. Have agility with elementary algebra.

Physics: have elementary knowledge of Newtonian kinematics and dynamics.

Others: maintain an open attitude and good study habits that allow taking the subject up to date.

Objectives and Contextualisation

Expand knowledge of classical mechanics, essential to understand more advanced subjects. Introduce the student into the world of special relativity, which is an essential part of modern physics.

Help the student to reach the understanding of the fundamental concepts and the formalism of these disciplines. Develop your ability to deal with exercises and problems of an intermediate level and/or that do not fit a specific typology. Develop analytical skills. Prepare the student to deepen and expand knowledge in more advanced subjects.

As a more specific objective in terms of special relativity, training the student in the use of Lorentz transformations to describe events from different reference systems and solve the most common paradoxes of special relativity.

Train the student in the application of the elementary principles of fluid physics.

Competences

- Carry out academic work independently using bibliography (especially in English), databases and through collaboration with other professionals
- Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, and before both specialist and general publics
- Develop critical thinking and reasoning and know how to communicate effectively both in the first language(s) and others
- Develop independent learning strategies
- Develop strategies for analysis, synthesis and communication that allow the concepts of physics to be transmitted in educational and dissemination-based contexts
- Formulate and address physical problems identifying the most relevant principles and using approximations, if necessary, to reach a solution that must be presented, specifying assumptions and approximations
- Know the fundamentals of the main areas of physics and understand them
- Respect the diversity and plurality of ideas, people and situations
- Use mathematics to describe the physical world, selecting appropriate tools, building appropriate models, interpreting and comparing results critically with experimentation and observation

Learning Outcomes

1. Analyse and interpret the main experiments related to basic physics.
2. Analyse certain open questions in contemporary physics and explain them clearly.
3. Apply Newton's laws to simple problems of particle dynamics and those of fixed-axis rigid bodies.
4. Apply the Bernoulli and Poiseuille equations for fluids.
5. Apply the principles of relativistic conservation to shocks and particle decay.
6. Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, in front of both specialist and general publics.
7. Contrast the sharpness of mathematical results with margins of error in experimental observations.
8. Correctly use principles of conservation.
9. Describe the Bernoulli and Poiseuille equations for fluids.
10. Describe the Lorentz transformations.
11. Describe the basic paradoxes of relativistic kinematics.
12. Describe the use of the Doppler effect in astronomical measurements.
13. Develop critical thinking and reasoning and communicate ideas effectively, both in the mother tongue and in other languages.
14. Develop independent learning strategies.
15. Identify situations in which conservation principles are useful.
16. Interact across diverse areas of basic physics.
17. List and describe Newton's laws.
18. Make mathematical rigor compatible with approximate physical modelling.
19. Outline and resolve the static equilibrium conditions of simple systems.
20. Relate the basic concepts of physics with scientific, industrial and everyday subjects.

21. Respect diversity in ideas, people and situations.
22. Select good variables and carry out correct simplifications.
23. Use complex numbers.
24. Use differential and integral calculus.
25. Use linear transformations and matrix calculus.
26. Carry out academic work independently using bibliography (especially in English), databases and through collaboration with other professionals

Content

Classical mechanics

Kinematics of the point in one, two and three dimensions. Dynamics of the material point: laws of Newton. Systems of inertial and non-inertial references. Relativity of Galileo. Dynamics of particle systems. Linear momentum. Mass center. Conservation of the linear moment. Moment of a force. Angular moment. Static of solids. Work and energy Conservative forces, potential and mechanical energies. Introduction to the dynamics of rigid solids (fixed or parallel rotation axes). Moment of inertia.

Fluid mechanics

Perfect fluids. Pressure and density Bernoulli equation. Applications: static and dynamic of perfect fluids.

Viscous fluids Viscosity. Law of Poiseuille. Fluid circuits.

Special relativity

Introduction. Einstein's Principle of Relativity. Principle of the constancy of the speed of light. Relativistic kinematics: Lorentz transformations; relativistic space-time. Paradoxes, applications and tests of relativistic kinematics. Relativistic Doppler effect. Definition of relativistic linear energy and momentum and conservation principles.

The (important) part of relativistic electrodynamics will look at Electricity and Magnetism. Other complementary parts will be treated in Waves and Optics.

Methodology

Face-to-face activities (supervised)

There will be two hours a week of theoretical classes and one class of (solving) problems. Additionally, eight hours of specialized seminars will be held in which each group will be divided into two subgroups in order to facilitate the interaction between students and instructors who will supervise the activities.

The theory classes will explain the key points of Newtonian relativity and mechanics, as well as the necessary developments to achieve (at a reasonable level) a consistent and well-structured body of doctrine that allows students to study their applications and solve them problems These problems will be solved and discussed in problem classes and specialized seminars.

Non-attendance activities (autonomous)

Students will have the content of theory classes and problems. Apart from the books (see the bibliography), students will have access (through the Virtual Campus) to the content of the theory classes and, as regards the class of problems, will have the statements that will be solved and discussed. Proposals will be proposed for problems whose assessment will weigh up to the mark of the subject.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Problem solving classes	14	0.56	4, 3, 18, 6, 19, 21, 22, 8, 24, 25
Theory classes	28	1.12	4, 3, 12, 9, 11, 10, 17, 16
Type: Supervised			
Specialized seminars	8	0.32	1, 5, 4, 3, 18, 7, 12, 9, 11, 10, 14, 17, 15, 19, 20, 16, 21, 22, 8, 24, 25
Type: Autonomous			
Autonomous Learning	91	3.64	2, 4, 3, 18, 12, 9, 11, 10, 14, 17, 15, 19, 20, 16, 22, 8, 24, 25

Assessment

The evaluations will be made in 3 calls and in each there will be an examination of theoretical issues and problems, and in the first two, in addition, a delivery of problems to solve at home individually or in groups, as indicated. The qualification of these deliveries can be revalidated in a corresponding exam. The agenda of the first call will include the part of Newtonian mechanics and the second the part of relativity and fluids. Each part will count equivalently in the final grade. The subject is considered approved "by partials" when the ***geometric*** mean of the notes of each part is higher than 5.0 (out of 10). These notes include the corresponding delivery.

The third and last call (of re-validation) consists of two written exams corresponding to each of the parts of the subject. Only students who have pending one or both parts and those who want to increase a grade should do so. They can only increase the grades (they have no effect if the grades are lower than those obtained in the previous exams). Those students who present themselves to both parts will have to answer only a selection of some questions (as indicated), since they will have the same time as the students who are examined for only one part. The final grade will be the ***geometric*** mean of the notes of each part. To participate in the necessary re-validation have been previously submitted to the two exams for evaluation corresponding to each part of the subject. There is no minimum qualification to be able to participate in the re-validation.

Theoretical questions will be brief and will not require complex calculations. They will asses the assimilation of the concepts developed in the classes.

The problems will be longer and will require more complex calculations. They will test the level of comprehension reached by each student, their ability to formulate mathematically the solution of the different sections and also their ability to calculate. These problems will not necessarily be variations of problems solved in the kinds of problems.

Observation. The two parts of the subject are fundamental pillars of the formation of a physicist. A good grade in one of the parts can not compensate for a poor grade in the other. That is why when calculating the global note we use the ***geometric*** mean instead of the ***arithmetic***. The geometric mean differs little from the arithmetic when the notes of each part are similar, but it penalizes the situations in which the notes are unbalanced, especially when one of them is very low.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Delivery of mechanical problems (recoverable int the written mechanical exam)	10%	0	0	1, 3, 18, 6, 14, 13, 26, 15, 19, 20, 16, 21, 22, 8, 24, 25

Delivery of relativity and fluid problems (recoverable in the written exam of relativity and fluid)	10%	0	0	5, 4, 18, 6, 14, 13, 26, 15, 20, 21, 22, 8, 24, 25
Final written exam or re-validation (optional for those who have the two previous exams approved)	up to 100%	3	0.12	4, 3, 6, 7, 12, 9, 11, 10, 14, 17, 19, 16, 8, 24
Written exam of mechanics (recoverable in the final written exam)	40-50%	3	0.12	1, 3, 18, 6, 7, 14, 26, 15, 19, 20, 21, 22, 8, 24, 23, 25
Written exam of relativity and fluids (recoverable in the final written exam)	40-50%	3	0.12	2, 5, 4, 6, 12, 9, 11, 10, 14, 13, 26, 22

Bibliography

Theory books

M. Alonso i E. J. Finn. *Física. Vol 1, Mecánica.* Addison Wesley Longman; 1 edición (2000)

Tipler+Mosca, *Física para la ciencia y tecnología,* ed. Reverté, 5a (2003) i 6a (2010) edición.

E. Massó, *Curs de Relativitat Especial*, Manuals de la UAB (1998). Specific for the relativity part.

Notes of the parts in the VC. Summarized and, therefore, difficult to assimilate if the theory classes have not been followed. They allow for an overview of the subject.

Problems books

Problems in the VC

Tipler+Mosca, *Física para la ciencia y tecnología,* ed. Reverté, 5a (2003) i 6a (2010) edición.